Ammonia Removal from Coal Fly Ash by Carbon Burn-Out

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Introduction

Carbon Burn-Out (CBO) has long been known as a very robust system for carbon removal for various types of ash feed stocks. Ash feed stocks containing carbon contents ranging from 7% to 90% have been successfully processed. To date, over 300,000 tons of coal fly ash have been processed using CBO.

CBO-processed coal fly ash exhibits excellent pozzolanic activity, consistent air entrainment, consistent LOI at 2.5% or less, and has gained excellent market acceptance in its market areas.

Recently, fly ash marketers have expressed concern about ramifications from post-combustion NOx reduction techniques using ammonia. Coal fired power generation facilities are under increasing pressure for NOx emission reductions. Recent United States EPA rule changes will require many coal fired utilities to meet NOx emissions limitations of 0.15 lbs./ MMBTU or less.

In order to meet these requirements, many utilities will use a combination of combustion management and post-combustion processes. Combustion management techniques include low NOx burners, over-fire air systems, gas re-burning technology and flue gas re-circulation. These methods can contribute to higher residual carbon levels in fly ash, especially when operating for maximum NOx removal.

Post-combustion processes include Selective Catalytic Reduction (SCR) and Selective Non-Catalytic Reduction (SNCR). Use of either of these treatment technologies will result in fly ash contaminated with ammonia slip, which may be then un-marketable, depending on the concentration.

Given the industry's concerns, Progress Materials conducted investigations as to ability of the Carbon Burn-Out process to remove ammonia residues from fly ash. This paper will present recent findings concerning ammonia removal in fly ash by Carbon Burn-Out and the fate of the released ammonia in the Carbon Burn-Out system.

Research Summary

Progress Materials' ammonia removal investigation approach was developed to accomplish three primary goals.

The first goal was to establish analytical protocols that would allow accurate measurment of ammonia concentrations for both solid and gas sample matrices.

Our second goal involved the determination of Carbon Burn-Out's efficiency in removing ammonia from fly ash. Data would be generated to determine fly ash ammonia concentration after Carbon Burn-Out processing.

The third goal is determining the fate of the liberated ammonia in the Carbon Burn-Out process. This investigation phase involves measuring gas phase ammonia concentrations and a system mass balance for ammonia.

In order to determine the effectiveness of ammonia removal by Carbon Burn-Out, several fly ash feed stocks of differing ammonia contents were processed. Processing was accomplished using Progress Material's one ton per hour pilot faciltiy located in Tampa, Florida.

Ammonia containing fly ash from several Eastern United States utilities was selected for processing. Fly ash ammonia concentrations ranged between 50 and 750 ppmw. Ammoniated fly ash used in this study was generated in both SCR and SNCR systems. Ammonia or Urea was used as the process reagent.

Coal fly ash samples were processed through Progress Material's one ton per hour continuous CBO pilot plant. Carbon Burn-Out's fluid bed technology provides heat and residence time dictated by conditions for optimal combustion of carbon found in fly ash. Fly ash residence times of forty five minutes and temperatures in the 1300°F range are characteristic of the CBO process. Kinetic theory suggest that CBO conditions should be ideal for ammonia removal and decomposition.

Both feed and product samples were analyzed for ammonia content. Ammoniated fly ash was tested by several different methods. Testing methodology for ammonia in fly ash is not well defined.

However, well-defined methods have been used for solid matrices in the environmental testing industry. Environmental methods, EPA 350.2, 350.3 and a rapid field technique developed by Boral Materials Technologies Inc. were selected for use in our testing program.

Table 1 illustrates results of four different fly ashes tested using three methods.

Table1:

EPA 350.2 Distillation (PPM)	EPA 350.3 (PPM)	Boral Procedure (PPM)
300	306	320
351	300	250
534	660	525
735	610	720

Table 2 illustrates ammoniated fly ash samples processed by Carbon Burn-Out. Ammonia content of both the feed and product, NOx control device used and reagent are illustrated.

Table 2:

Feed Ash (PPM)	Product Ash (PPM)	Control Device	Reagent
60	< 5	SCR	Ammonia
230	< 5	SNCR	Ammonia
300	< 5	SNCR	Ammonia
500	< 5	SNCR	Ammonia
650	< 5	SNCR	Ammonia
700	< 5	SNCR	Urea
735	< 5	SNCR	Urea

Results indicate that under normal Carbon Burn-Out operating conditions essentially all ammonia was liberated from the fly ash feed material.

The third phase of the study involved the determination of the fate of released ammonia in the flue gas. To quantify the extent of thermal decomposition of ammonia, flue gas ammonia concentrations were measured at the fluid bed exhaust and the exhaust stack.

The test method selected for ammonia concentration in flue gas was EPA CTM 027, “Procedure for Collection and Analysis of Ammonia in Stationary Sources.”

Initial results were found to be inconsistent. Baghouse Outlet sample produced an ammonia concentration of 114 ppmv while the bed exhaust yielded 20 ppmv. This data indicates that between 50 and 95 % of the ammonia introduced into the system is being thermally decomposed.

A second test was conducted to closely simulate full-scale CBO conditions. Simulation of full scale operating conditions was achieved by changing three pilot scale operating conditions. Sampling was conducted after the Carbon Burn-Out unit achieved steady state operations. Secondly, water cooling was eliminated and finally re-cycle ash was used for system cooling.

Results of testing which more closely duplicates full scale operations indicate that between 94 and 98% of the ammonia introduced into the system is being thermally decomposed. Both sampling points produced similar concentrations and decomposition efficiency.

Conclusions

Ammoniated fly ash was successfully treated by the Carbon Burn-Out process. Ammonia concentrations between 300 ppm and 750 ppm were evaluated and in all cases the Carbon Burn-Out process reduced ammonia concentrations below detectable levels.

Carbon Burn-Out technology has the necessary conditions for thermal decomposition of the liberated ammonia released from the fly ash. Full scale Carbon Burn-Out conditions result in 94 to 98% of the liberated ammonia undergoing thermal decomposition to harmless nitrogen and water.

Finally CBO pilot demonstrations proves that fly ash ammonia contamination can be eliminated without any process changes.